How to Grow *Aldrovanda vesiculosa* Outdoors

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Aldrovanda vesiculosa L. (Droseraceae) is a rootless aquatic carnivorous plant. (Figure 1) rapidly vanishing from Europe and possibly also from other parts of the Old World. The protection of this critically endangered species should not only aim at conserving its remaining sites (it does not help much in Europe) but active measures must be accepted as soon as possible. Recently, preparation of sterile tissue culture of *Aldrovanda* was demonstrated, its extensive propagation is on the way, and an experimental selection of suitable substitute sites succeeded in the Czech Republic. However, both approaches require a rich stock culture. Cultivation of *Aldrovanda* has often been described on an empirical basis (Saito, 1972; Haldi, 1974; Hanabusa, 1974; Ohtaki & Katagiri, 1974; Mazrimas, 1974, 1978; and Duval, 1990). Here, a reliable technique of outdoor cultivation of European *Aldrovanda* (from east Poland), based on a study of its ecology at Polish sites, is presented.

Generally, *Aldrovanda* requires warm and clean brownish water with a low mineral nutrient (nitrogen and phosphorus) concentration but a high CO_2 concentration, sufficient prey, and enough light. I cultivate it in a plastic container (1 m^2; Figures 2 & 3) but a small garden water lily pool can also be used. The cultivation technique very much resembles that described by Hanabusa (1974) and reminds me of the character of the species' richest natural habitats in Europe. The suitable substrate must be rich in organic matter but poor in mineral nutrients. A thin layer (ca. 0.5 cm) of brown mud from a swamp or gardener's peat placed on the container bottom is topped by a 6—8 cm layer of washed sand or gravel. The thin layer of mud or peat on the bottom is not necessary and only supports the growth of emergent vegetation. Small plants of common reed and the sedges *Carex rostrata* or *C. gracilis* were loosely planted in the sand. The plants affect the cultivation medium like added litter and moderate light. Litter from those sedges is the best substrate; litter of other sedges or common reed may also be used. This litter has similar properties as rice straw, widely used by the above authors. An optimum litter layer is 2—3 cm thick. New litter should be dipped in warm water for several hours to wash out excessive tannins. The litter is a key component for *Aldrovanda* cultivation: it decomposes slowly, continuously releasing humic acids and tannins which are necessary for its growth and development and partly checks the growth of filamentous algae. Furthermore, the litter gradually releases mineral nutrients and CO_2 by its decomposition and keeps the pH between 6.8—7.4.

I emphasize that a high CO_2 concentration (above 0.1 mM, i.e. 4.4 mg l^{-1}) in water is necessary for vigorous growth of *Aldrovanda*. As CO_2 concentration and pH are closely interrelated, a lowering of pH leads to an increase in free CO_2 concentration. However, pH itself is not too important as *Aldrovanda* can grow well within the pH range of 4.0—7.8, the optimum being between 6.0—7.2. Any tap water may be used as the plant is very tolerant of carbonate hardness (i.e. HCO_3^- concentrations of 5—300 mg l^{-1}). The optimum water colour is that of a 3—5 times diluted light ale. When the water is too dark "mirrors" of oxidized tannins are formed on the water surface and *Aldrovanda* plants are short. In this case, removal of a part of the litter and a partial exchange of the water help immediately. As shown in

Table I, the cultivation water was rather poor in mineral nutrients (NO_3^-, NH_4^+, HPO_4^{-2}) which controls algal growth. However, zooplankton must occur in the water to support plant growth. Ostracods and chydorids usually reproduce spontaneously in the brown water. If so, zooplankton does not need to be added. It is also convenient to add some species of water snails that do not graze on higher plants (e.g. *Planorbis*). They also graze on filamentous algae and the smallest snails are very often trapped by *Aldrovanda* plants. The optimum water depth is 20—30 cm.

The optimum temperature for the growth of European *Aldrovanda* is 25—28°C. Temperatures up to 33°C are tolerated but higher ones are not suitable. Obviously, high temperatures of 29—31°C are required to induce flowering. Night water temperature should be 6—10°C lower than the day temperature. To avoid overheating and algal growth during a hot summer, additional shading of the container is necessary, especially in subtropical countries. There, it is also possible partly to bury the container in the earth for its cooling. *Aldrovanda* is photophilous but shading to 30—60%, temporarily to 20%, of full sunlight is useful in summer. As seen in my photographs, some floating aquatic plants (*Hydrocharis morsus-ranae*, *Stratiotes aloides*, *Salvinia spp.*) may also be loosely planted to shade the water and take up excessive mineral nutrients. Their density must be controlled. A partial exchange of old litter with new, and removal of dead plant residues suppress the growth of algae. Indoor cultivation of *Aldrovanda* is rather difficult.

Healthy *Aldrovanda* plants are 8—20 cm long, richly branched with 5 mm traps, and propagate fast. One plant (from a turion) can give rise to 15—30 daughter plants over one season. Overwintering of the European plants is quite easy in the temperate zone with cold winters, but may be difficult in subtropical countries. As a result of the long-term decrease in water temperature below about 16°C, rhomboid turions which are 6 mm long start to develop at the end of September. They become fully ripe in October, probably only in light and cold water below ca. 8°C, when the shoots have decomposed. In countries with a regular ice cover, clean turions should be stored in the cultivation water in a refrigerator at 3—5°C and the outdoor container should be emptied. In regions without ice formation, if the turions are not distinctly formed, it is better to let them float on the water in the container over winter. In April, the old litter must be removed and new litter added, and the container may again be filled with water but the sinking of the turions to the litter on the bottom should be avoided.

As a result of the extremely hot summer of 1994, 138 plants flowered and 17 of

Figure 1: *Aldrovanda vesiculosa* flowering in cultivation. The flowers are 6—7 mm in diameter, July 1994. Photograph by L. Adamec.

Figure 2: Outdoor cultivation of *Aldrovanda vesiculosa*, July 1993. Photograph by L. Adamec.

them even produced seeds. The same cultivation technique may be used to all aquatic *Utricularia* species.

Throughout the 1994-1996 growing seasons, the plants suffered from a disorder. Shoot apices stopped growing as early as in the middle of June and were small, yellowish, flat, and were without typical bristles. As the disorder progressed, the apices became brown and began to die. Damaged plants produced non-functional turions. This disorder has not been observed in naturally occurring plants. Moreover, damaged plants became healthy very quickly once placed in natural habitats. Since no parasite was ever observed in the damaged apices, it was evident the disorder resulted from a mineral nutrition problem, namely a Boron deficiency. After H_3BO_3 was added to the culture medium (0.6 mg l^{-1}), plant growth resumed after a few weeks and the shoot apices returned to good health. It is presumably possible to prevent the disorder by adding a greater amount of clay to each container, since a variety of micronutrients, including Boron, will be continuously released from this substrate. At the first sign of the disorder, it is recommended to add H_3BO_3, striving for a final concentration of 0.5 mg l^{-1}.

Figure 3: Outdoor cultivation of flowering *Aldrovanda*, July 1994. Photograph by L. Adamec.

Table I: Water chemistry in the container with flowering *Aldrovanda*; summer 1994.

Date	NO_3-N (µg l^{-1})	NH_4-N (µg l^{-1})	PO_4-P (µg l^{-1})	K (mg l^{-1})	Ca (mg l^{-1})	Mg (mg l^{-1})	Humins (mg l^{-1})	O_2 (mg l^{-1})	HCO_3^- (mmol l^{-1})	CO_2 (mmol l^{-1})	pH
26 July	4	34	10	1.58	17.9	4.5	26.8	6.4	1.03	0.23	7.0
15 Aug.	0	22	12	0.18	19.5	5.3	—	11.2	1.20	0.11	7.4

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